The effect of temperature and cataclastic deformation on salinity, halogen systematics and metal transport capacities of continental basement brines – an experimental approach

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Deep crustal, highly saline brines (with salinities up to 26 wt.% NaCl equivalent) are a global phenomenon within the continental crust. They are invariably characterized by Cl as the predominant anion and low Cl/Br ratios (below seawater, 288). Besides the scientific interest, these fluids are often cited as metal source in hydrothermal ore deposits and therefore are of great economic value. Although these fluids are known since decades, the origin of Cl and transition metals in these fluids is still highly debated.

We performed leaching experiments on typical crystalline basement rocks (granite and gneiss) and a redbed sandstone and their mineral separates (feldspar, quartz and biotite) at variable T (25, 180, 275 and 350°C) and P (ambient pressure, 0.9, 1.4 and 1.9 kbar) with ultrapure water and 25 wt.% NaCl solution as solvents. For these experiments we used three grain-size fractions (> 0.005, 0.063-0.125 and 2-4 mm) and variable fluid/rock ratios (10 to 1.1).

We show that the mode of modification of the fluid chemistry during water-rock interaction strongly depends on the grain size of the rock: smaller grain size results in lower Na/Cl and Cl/Br ratios as well as vastly higher chlorinity (by a factor of up to 40) of the resulting fluid. Cl/Br ratios of the fluids are consistently below the Cl/Br of seawater and lower than their respective whole rock ratios. Lead, Zn, Cu and W are released in significant amounts by feldspar and fluid inclusions in quartz, while Zn, Ni, Cu and As are released by biotite during hydrothermal alteration. Therefore, our experiments confirm that crystalline rocks have a large potential to serve as metal source for hydrothermal deposits of transition metals.